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WINDOWS
NUMBER 13

Aluminum Replacement Windows with Sealed Insulating Glass and Trapezoidal Muntin Grids

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MILLS NOS. 5, 6 and 8 Suffolk Manufacturing Company (Wannalancit Office and Technology Center)

Lowell, Massachusetts

The three connected buildings of the former Suffolk Manufacturing Company in Lowell, known as Mills Nos. 5, 6 and 8, were built in 1862 (No. 5) and 1880 (Nos. 6 and 8), at a time when the city of Lowell was one of the predominant centers of the textile industry in the United States. Located within the Locks and Canals National Register Historic District, this impressive complex of mill buildings housed in more recent years a synthetic textile weaving operation under the ownership of the Wannalancit Textile Company. In 1981 the buildings were acquired for development as the Wannalancit Office and Technology Center, a project involving 286,000 square feet of rental space.

The long unbroken pattern of some 900 small-paned windows dominates the facades of these buildings and is clearly their most significant architectural element. At the time of the conversion to an office complex, the original double-hung windows, arranged with 12-over-12 lights, had survived in Mills Nos. 6 and 8, but virtually all the sash and some of the frames had been removed form Mill No. 5 (see figure 1).

Design Problem

Appropriate window treatments quickly emerged as the major preservation design problem in this $8.5 million rehabilitation. From the outset it was established that the appearance of the historic windows would have to be retained on all elevations; this meant duplicating such features as the reveal, trim detailing, double-hung configuration, and particularly the multi-pane appearance created by the muntin pattern.

The first step was to evaluate the condition of the original windows that had survived in Mills Nos. 6 and 8 to establish whether the historic windows were repairable. Based on an indepth inspection, the windows were judged beyond reasonable repair due to their deteriorated condition (see figure 2). Once the decision to replace the historic sash had been reached, consideration was given to replacing them with matching custom-made wooden windows. The developers obtained a quotation of $875 per window for fabrication and installation of 900 matching wooden replacement units, with integral muntins in a 12 light configuration and the addition of an interior storm panel. Due to cost, the developers decided to consider other alternatives.

The decision was reached to evaluate the cost and appearance of a non-wooden, double glazed, pre-finished, single-hung window with applied muntins grids on the exterior rather than integral muntins. The objective was to determine whether a non-wooden commercially available window could closely match the configuration and appearance of the historic windows. To achieve this result, several window manufacturers were invited to install field mock-ups. Six manufacturers responded—

Deteriorated historic windows should be repaired rather than replaced wherever possible. In the event replacement is necessary, the new windows should match the historic ones in design, color, size, configuration, reflective qualities, shadow lines, detail and material. Only where it is not feasible to match the historic fabric should substitute window material be considered for use and only when it is shown through such means as field mock-ups that it is possible to match closely both the detail and the overall appearance of the historic windows.

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Figure 1. The original wooden double-hung windows consisted of 12 lights in both the upper and lower sash. Photo: Charles Parrott

Figure 2. The condition of the windows varied considerably. Shown here is a typical case where the frame, sill and sash were beyond repair. Photo: Charles Fisher

four aluminum windows were installed as part of the selection process, along with the one vinyl and one aluminum-cladded wooden unit.

The criteria used in evaluating the field mock-ups included performance and cost, but focused primarily upon appearance due to the significant contribution of the windows to the historic character of the building. In considering the various proposed window replacements, criteria established for the window work included:

1. Retaining the historic reveal of the window—the location of the sash relative to the outer wall surface.
2. Matching the double-hung window style and having sufficient depth between the glass planes of the upper and lower sash to create an appropriate shadow where the upper sash overlaps the lower sash.
3. Matching as closely as possible the proportions and the width of the sash members, such as the stiles and meeting rails.
4. Duplicating the glass pattern of 12 lights in each sash.
5. Having an applied muntin grid that was not only permanent but that closely approximated the historic shape and width and that also had sufficient depth to create good shadow lines.
6. Having appropriate paint color.
7. Retaining the appearance of the historic frame and brick molding details.
8. Incorporating energy conservation features.

One of the aluminum window mock-ups did contain real muntin bars, dividing each sash into 12 individual, double-glazed lights. The width of the muntins, however, was far too wide. With the insulating glass, there were technical limitations that prevented the manufacturer from making any major modifications, especially in the size of the muntins.

Design Solution

One of the aluminum windows did stand out as the most promising match of the historic units, and with further modifications eventually was selected as the replacement window for the project. The replacement unit was one of the manufacturer's standard single-hung sash models modified to accept an exterior muntin grid on each sash, creating the appearance of 12 divided lights. The window assembly also incorporated a custom-extruded and curved aluminum pan over the existing wood frame and trim.

Frame and Brick Molding

The historic wooden frames were retained and used as a structural subframe on which to fasten the new aluminum trim and frame members. A custom extruded aluminum pan was used that fitted snugly around the exposed face of the original frame and maintained the face width and depth of the casing at both jamb and head. The original wooden brick molding (which covers the joint between the masonry and the window frame) was fitted with a custom-extruded aluminum pan (see figure 3).

At the head of the wooden frame, the aluminum pan was constructed in two pieces, both custom extrusions. The flat face of the lower piece was cut on a curve to follow the segmental curve of the masonry opening. The upper piece, which replaced the original brick molding, was custom-bent to the segmental curve and blind attached to the lower piece of aluminum (see figure 4). An additional aluminum pan was fitted tightly to the original wooden window sill (see figure 5).

When the aluminum window frame was inserted, it included its own sill in the place where the bottom rail abutted the sill of the original window. This second sill unfortunately added an element not present in the original window (see figure 6).

Muntin Grid and Sash

A new type of applied muntin grid was developed to give the appearance of a 12 light division in each sash. To avoid the flatness of most applied metal muntin grids, the aluminum sections were extruded in a trapezoidal shape to resemble more closely the historic shape of the rabbeted wooden muntin and beveled putty seal. The 3/4" wide muntin bar has an exterior depth of 1/2", dimensions nearly identical to those of the original wooden windows. Even though the muntin bar does not extend through to the inside, the field mock-up showed that the shadow lines were sufficiently strong to create from the exterior the overall effect of a 12 light sash.

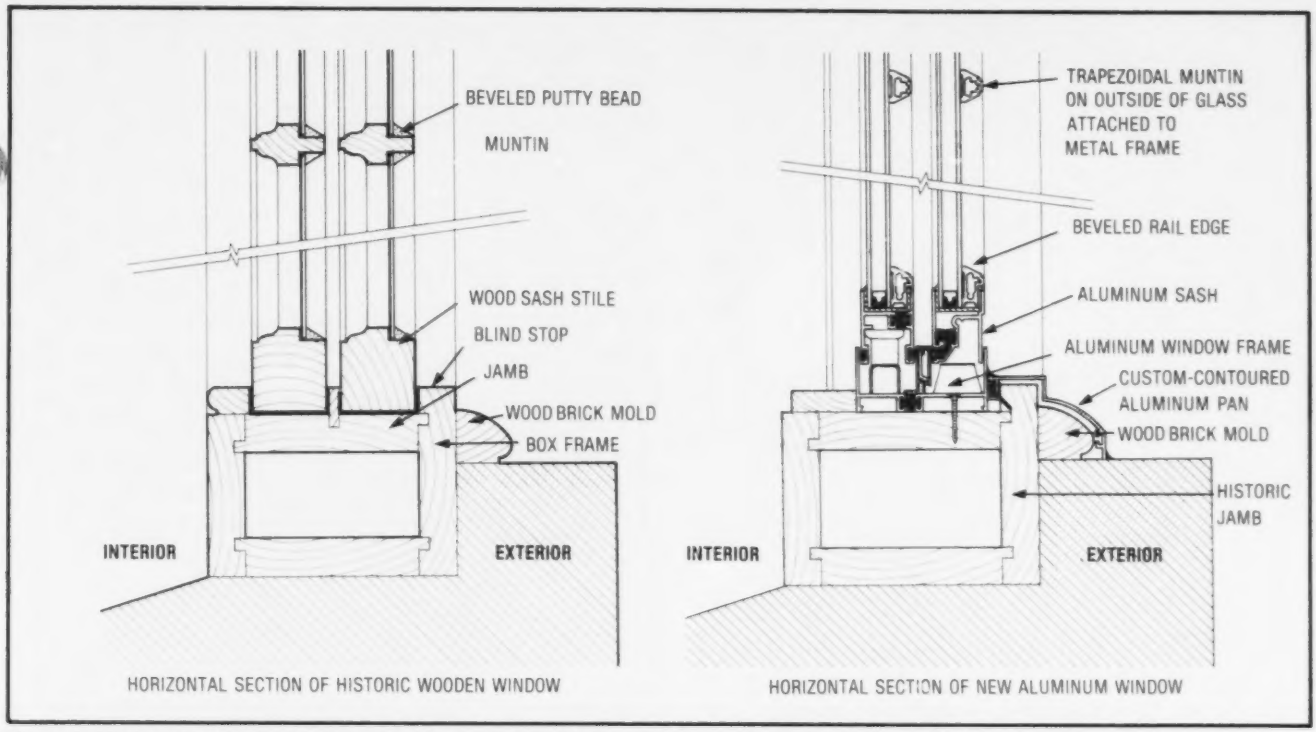

Figure 3. Horizontal section of both the original wooden window and the replacement aluminum window. Drawings: Penelope Watson

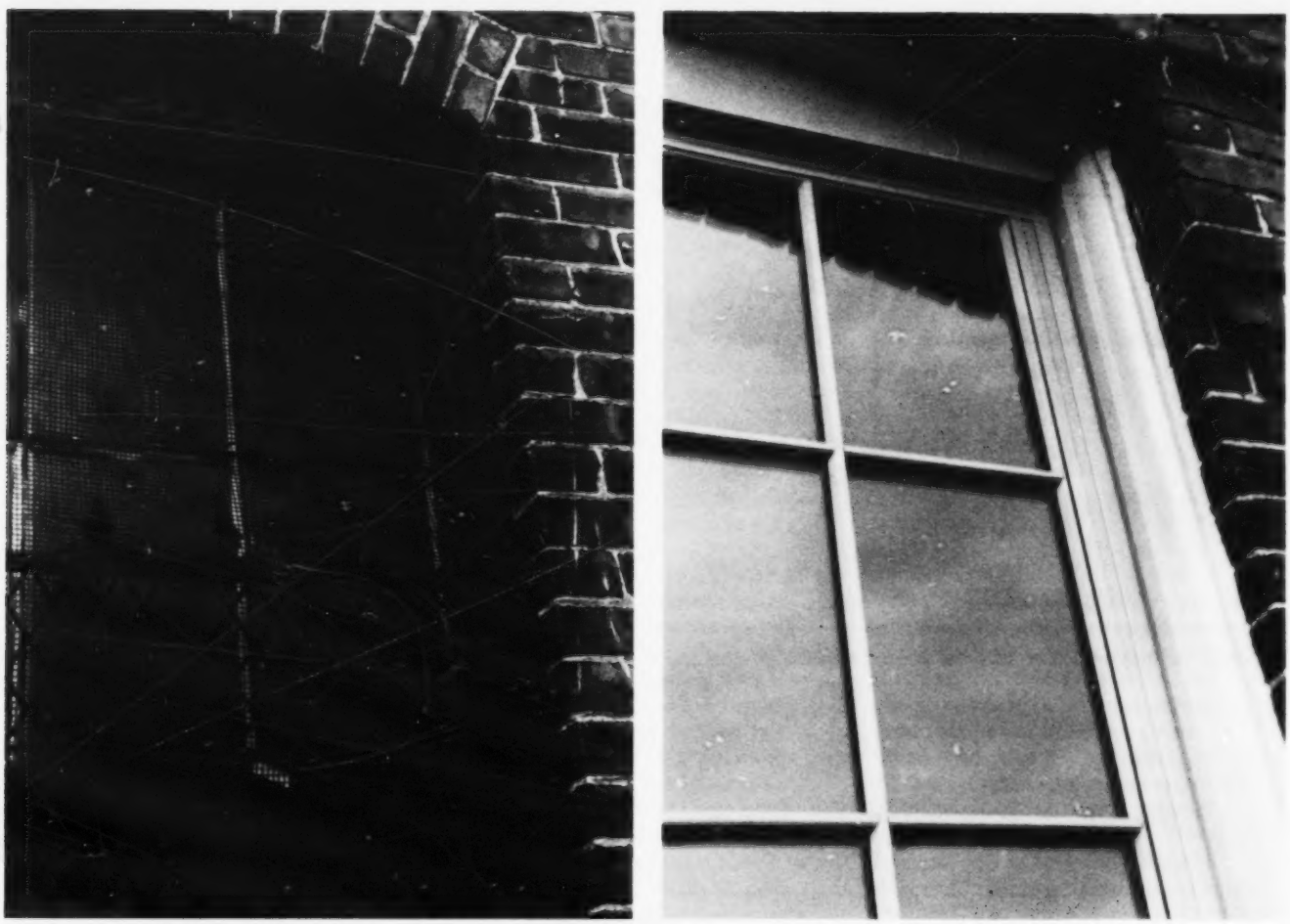

Figure 4. A custom-extruded aluminum pan was installed, duplicating the brick molding detail and, at the head of the frame, custom bent to follow the segmental curve of the masonry opening. Photos: Charles Fisher

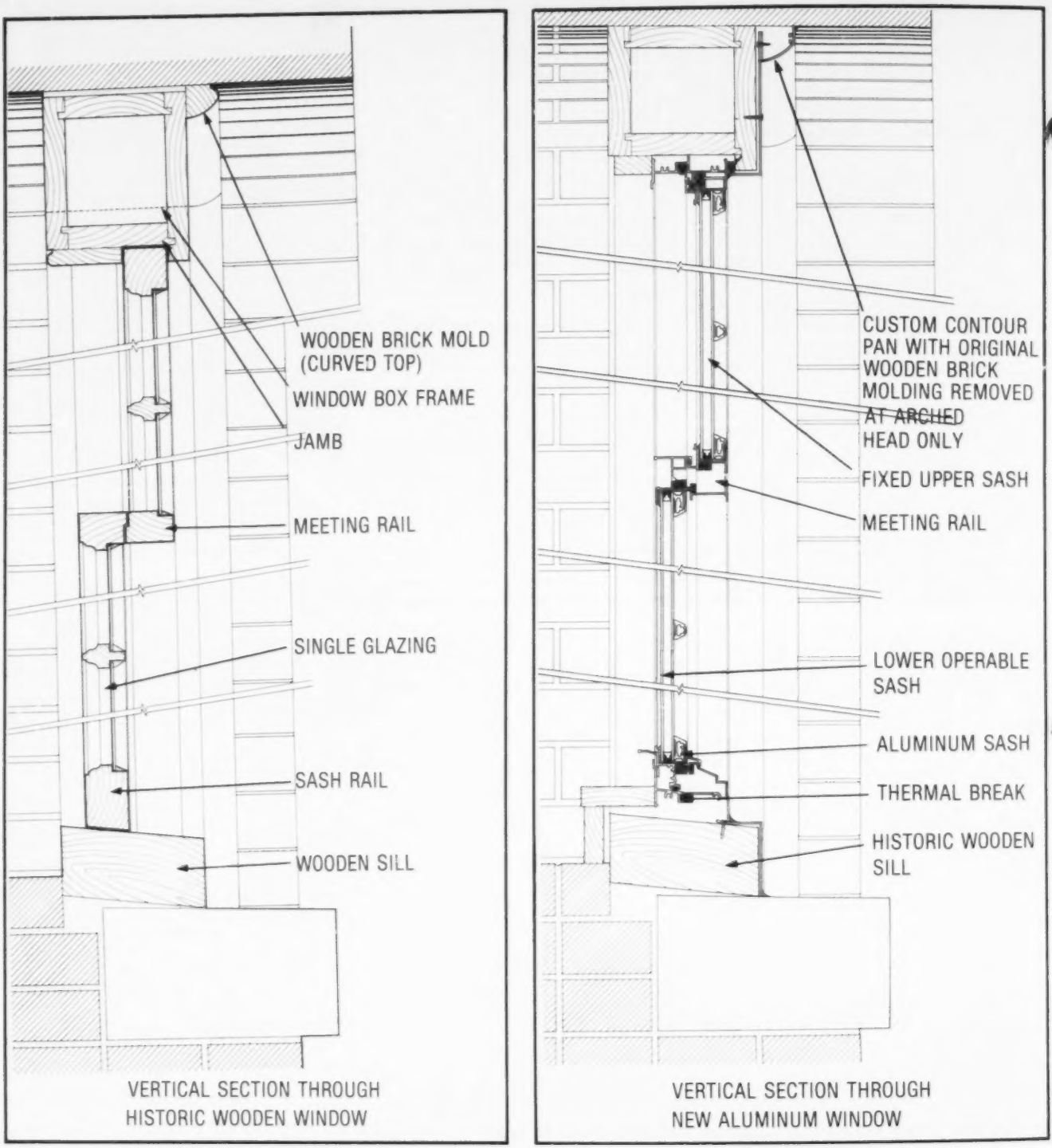

Figure 5. Vertical section of both the original wooden window and the replacement aluminum window. Drawings: Penelope Watson

Figure 6. The manufacturer's stock window used for the project unfortunately created the appearance of a double sill, which the historic window never had. Photos: Charles Fisher

The manufacturer's stock sash accommodated the muntin grid with only minor modification. The stock sash contained a single light of 7/8″ thick insulating glass (two 1/8″ glass panes separated by a 5/8″ air space) fastened in a 1 1/4″ thick sash. As modified for the muntin grid, the insulating glass was narrowed to 1/2″ (two 1/8″ glass panes separated by a 1/4″ air space) to provide the depth for the grid to be contained within the sash. The beveled edge of the muntins was continued around the glass edge of the rails and stiles as well, in order to duplicate the angled putty seal line of the original sash. The grid was securely set into the sash frame as the sash was being assembled.

Visually, the exposed face of the aluminum window is wider than the wooden sash because the face of the new frame and sash are practically in the same plane and read as one. As a result, the face width of the new upper sash stiles (which visually includes the vertical face of the new aluminum frame) is wider (2 1/2″ vs. 1 1/2″) than the face width of the historic sash (see figure 4). At the lower sash, the new frame stands out as an additional member not present in the historic windows.

An increase in size also occurs at the meeting rail. The resulting encroachment on the historic glazed area is noticeable, though fortunately the large window opening lessens the visual impact of the heavier meeting rail. Redesign of the meeting rail to achieve a narrower face dimension was not attempted for this project because any change in these extrusions would have necessitated retesting of the window with the new meeting rail to determine its compliance with the standard Architectural Aluminum Manufacturer's Association (AAMA) specification for this window—a costly and time-consuming process.

Custom Color

Windows of Lowell's textile mills were usually painted light colors—often white—in the 19th century. Through paint research, it was established that an off-white was the original color of the windows at the Suffolk Mills; later in the 20th century they had been painted dark green. In an effort to recreate the light value of the original color without necessarily duplicating the exact hue, a cream color was selected. The thermosetting acrylic enamel paint was factory-applied to the extrusions before window assembly. Due to the large number of windows involved, the cost of the custom color was negligible and did not affect the construction schedule.

Window Fabrication and Installation

The historic window openings were prepared for the new aluminum windows by removing interior sash stops, the parting beads, sash pulleys and exterior brick molding at the head. For each window, the head, jamb and sill panning was then applied using the extrusions custom-made for this project.

The new window units were delivered to the site preassembled. The operable bottom sash was temporarily removed from the new aluminum window unit, and the unit (frame and fixed upper sash) was set into the old sash opening and screwed into the pulley stiles of the old window frame. Finally, the operable bottom sash was installed and all exterior joints caulked. Later, flat wood trim was placed around the interior of the opening to finish the interior joints and complete the enclosure of the original frame.

Project Evaluation

The replacement of the windows at the Wannalancit Office and Technology Center was a pioneering effort in using stock aluminum windows specifically modified for large historic industrial buildings with single-hung sash and multiple divided lights. The results achieved in adapting these existing stock units are noteworthy, including the high cost savings achieved by adapting existing units rather than developing and producing completely new aluminum windows. Both the developers and the preservation review groups involved felt that the performance criteria and visual considerations were satisfactorily met in this case, especially considering the then-prevailing state-of-the-art. Subsequent modifications in similar window systems over the past several years have achieved even a closer match of the visual characteristics of historic windows.

Insulation and infiltration values of the new aluminum windows were considered acceptable by the owner; the modifications made to the stock units only minimally reduced the energy efficiency. The insulation U-value of the window with 1/2″ insulating glass measures .62 while the 7/8″ insulating glass achievable in the same window without the muntin grid would have been .54. The infiltration rating for this DH-A2.5 H.P. specification window with a fixed upper sash and 7/8″ insulating glass without the grid is .08 cfm per foot of crack—well below the .50 maximum allowable set by AAMA. Presumably the 1/2″ insulating glass with grid in the same window had little effect on the air infiltration rating, although this assembly was not tested. Besides the energy savings that will be realized, the maintenance cost of the windows over the first 20 years is anticipated to be less than wooden windows, principally because of the factory finish.

The windows likely will require more frequent cleaning than normal. Atmospheric dirt deposited on the exterior glass surface has tended to wash behind the muntin, depositing a slightly heavier than normal dirt film just below the muntin as the dirt washes down under normal weathering. Fortunately both the fixed upper and the operable lower sash are removable from the inside for cleaning.

For purposes of preserving the historic appearance of the building, matching the visual details of the historic wooden windows at the Suffolk Mills was of foremost importance. It was felt that the aluminum window maintained the overall appearance of the original window. This was achieved by retaining the historic frame width, using custom aluminum brick moldings (including a curved head molding), setting the two sash in offset glazing planes as in the traditional double hung window, incorporating an exterior grid on each sash simulating the trapezoidal muntins of an authentic wooden window, and using appropriate paint color (see figure 7).

Development of these window features shows that the aluminum window industry can make improvements in window lines to meet the needs of the historic retrofit market and that such changes can be made without altering the operating characteristics inherent in these windows. Other aluminum window designs no doubt can also be successfully modified to achieve similar results, although some custom work, such as special extrusion for pannings and grids, painting finish, and fitting will often be necessary.

The philosophical issue of using what is essentially an artificial recreation of a true divided light muntin grid was considered during the development of this project. The primary concern in this project was visual—not physical—separation of the panes. Even if cost were not a concern, the state-of-the-art development of insulating glass muntin widths narrow enough for divided lights with muntins under 1″ wide had not been achieved in an aluminum window. The fabrication of a deep trapezoidal exterior muntin grid in aluminum—one that was permanently and solidly attached—was something of a milestone itself. If not the first instance of its use in this way, it was one of the earliest. The initial response to the request for the exterior grid was the supply of a double ovolo molding extrusion by the manufacturer. Through discussions with representatives of the Lowell Historic Preservation Commission and the National Park Service, the developer and the window manufacturer were persuaded that the trapezoidal shape should instead be used, as it was the historically correct shape for the exterior of the muntin, and one far more appropriate in the replacement unit.

The window solution at Suffolk Mills was an important improvement over past efforts in similar rehabilitation of large scale historic mill complexes where aluminum windows had been installed as replacement units. While in many cases the historic character of specific buildings would preclude the use of such a retrofit solution, it has applicability to many large-scale buildings where the existing windows are beyond repair and where replacement with wooden windows, even though upgraded in thermal performance, is not a viable alternative. The experience of this project also suggests that opportunities exist for still other refinements of aluminum window design and detailing. Foremost, it illustrates the need for advance planning and the willingness of the developer, the window manufacturer and preservation groups to work together, as they did in this case, to improve the quality of replacement windows installed in historic buildings.

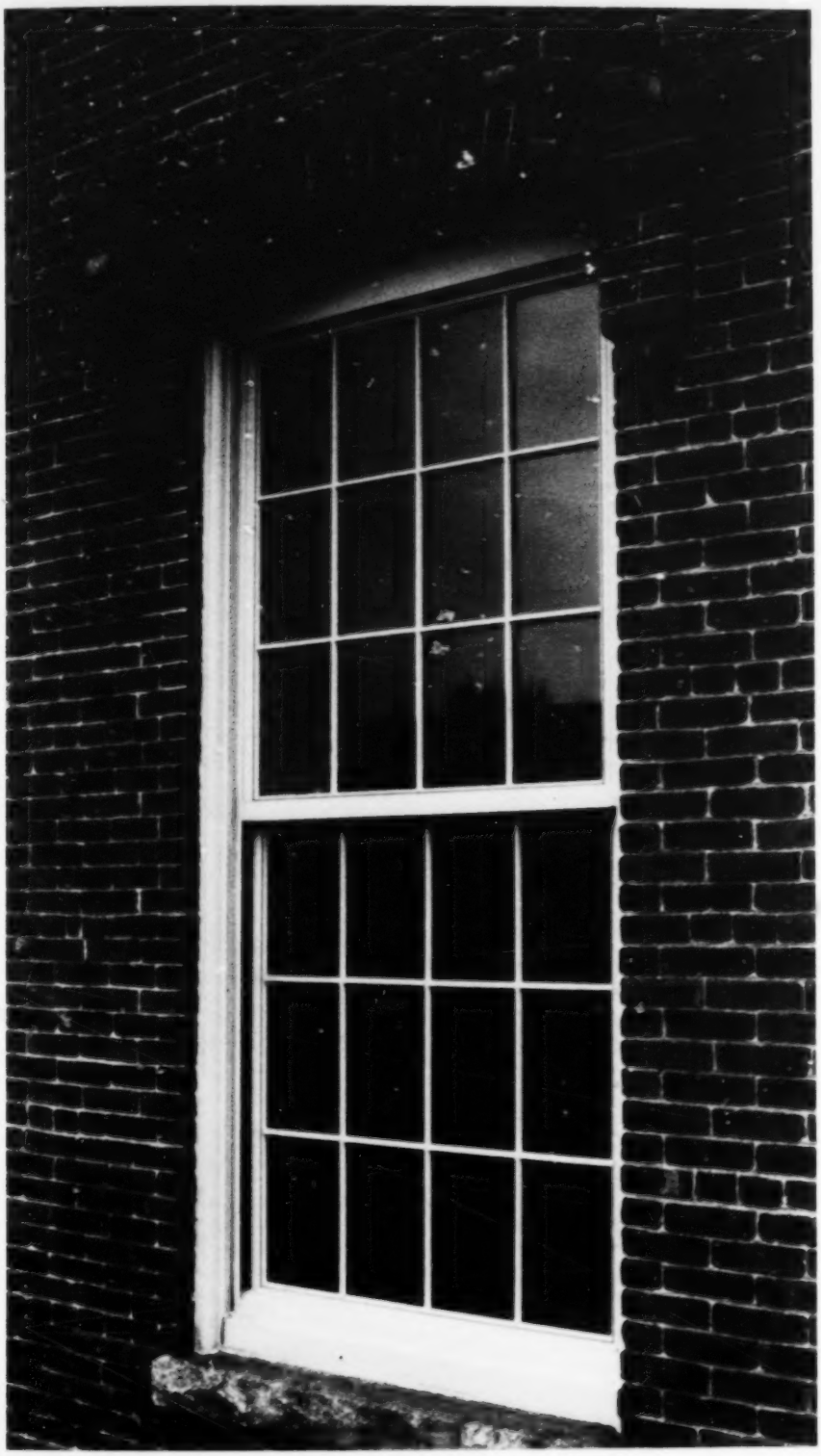

Figure 7. Replacement window after installation. Photo: Charles Parrott

PROJECT DATA:

Buildings:
Wannalancit Office and Technology Center
Mills Nos. 5, 6 and 8 of the former Suffolk Manufacturing Company
650 Suffolk Street
Lowell, Massachusetts

Owner:
Dobroth and Fryer, Inc.
650 Suffolk Street
Lowell, Massachusetts

Project Date: Spring 1983

Architects:
Perry Dean Rogers, Inc.
177 Milk Street
Boston, Massachusetts

Window Manufacturer:
North American Manufacturing, Inc.
551 Concord Street
Holliston, Massachusetts

Window Installer:
Atlantic Window Co.
15 Carr Road
Saugus, Massachusetts

Preservation Review Agencies:
National Park Service
Lowell Historic Preservation Commission
Massachusetts Historical Commission

Project Cost:
The total fabrication and installation cost was $415 each for 906 windows on Mills Nos. 5, 6 and 8. The supply cost was $240 per window; the remaining $175 included removal of the old window and the installation and trimming of the new window. The per square foot cost was $12.20 on windows 4' wide by 8 1/2' tall. An additional 250 windows will eventually be installed in Mill No. 10.

This PRESERVATION TECH NOTE was prepared by the National Park Service in cooperation with the Lowell Historic Preservation Commission, and the Center for Architectural Conservation, Georgia Institute of Technology. Charles E. Fisher, Preservation Assistance Division, National Park Service, serves as Technical Coordinator for the PRESERVATION TECH NOTES. Special thanks go to the following people who contributed to the production of this Tech Note: Penelope S. Watson of the Lowell Historic Preservation Commission and Preservation Assistance Division staff, particularly Michael J. Auer, Terry Robinson, Brenda Johnson, and Janet Thomas. Cover Photo copyrighted by Jim Higgins.

This and many of the PRESERVATION TECH NOTES are included in "The Window Handbook: Successful Strategies for Rehabilitating Windows in Historic Buildings," a joint publication of the Preservation Assistance Division, National Park Service, and the Center for Architectural Conservation, Georgia Institute of Technology. For information, write to the Center for Architectural Conservation, P.O. Box 93402, Atlanta, Georgia 30377.

PRESERVATION TECH NOTES are designed to provide practical information on innovative techniques and practices for successfully maintaining and preserving cultural resources. All techniques and practices described herein conform to established National Park Service policies, procedures, and standards. This Tech Note was prepared pursuant to Federal tax laws which direct the Secretary of the Interior to certify rehabilitations of historic buildings that are consistent with their historic character; the advice and guidance provided in this Tech Note will assist property owners in complying with Federal requirement for tax incentives for historic preservation.

Comments on the usefulness of this information are welcomed and should be addressed to PRESERVATION TECH NOTES, Preservation Assistance Division-424, National Park Service, P.O. Box 37127, Washington, D.C. 20013-7127.

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